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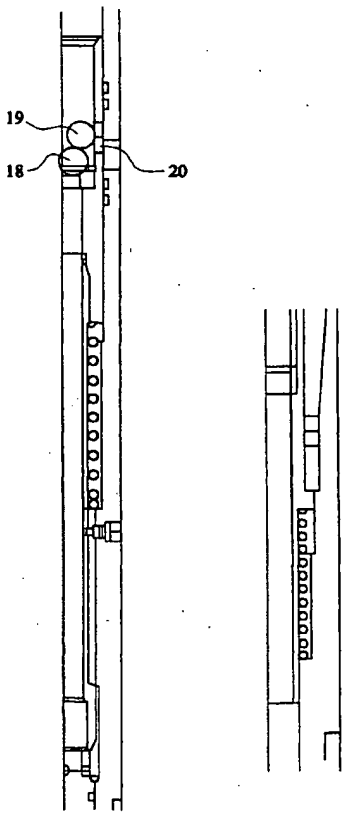
(54) Title: BY-PASS TOOL FOR USE IN A DRILL STRING



(57) **Abstract:** A by-pass tool (10) which is insertable into a drill string comprising: a transverse by-pass port in the wall of the casing (14); a control sleeve (15) mounted in the casing for axial movement between first and second end positions; a ball-receiving seat provided in the tool to receive a first deformable activating ball (18) to be launched down the drill string when it is required to adjust the tool from its first operating mode to its second operating mode; and, a releasable locking arrangement (23, 24) which can be actuated to a locking mode by the movement of the sleeve to the second end position in order to hold the sleeve in the second end position, said locking arrangement being disabled by movement of the first activating ball (18) lengthwise of the tool during adjustment of the tool from the second mode to the first mode.

WO 01/90529 A1

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

BY-PASS TOOL FOR USE IN A DRILL STRING

This invention relates to a by-pass tool for use in a drill string which is being utilised to drill for fluid reserves, such as oil, gas or water.

During drilling operations to extract oil or gas reserves, problems often arise because of differences in the pressure in the geological formation being drilled and at the surface, or between the pressure of the usual drilling mud being used and the formation pressure. Three common major problems which occur comprise blowout, differential sticking, and circulation loss.

With a view to mitigating these problems, it is known from US 5 499 687 to provide a by-pass tool which is insertable into the drill string and which comprises a tubular casing which normally defines a through-flow passage for fluid, but which has a by-pass port in its side wall which is openable or closable depending upon whether or not by-pass flow is required. The by-pass port is controlled by a shiftable sleeve mounted within the tubular casing and which is normally spring loaded to a position blocking communication between the through-flow passage and the by-pass port.

When it is required to activate the tool, a deformable ball is launched down the drill string from the surface, and which moves along the drill string (under gravity action and/or by fluid pressure acting on it), until it comes to rest against a ball seat provided on an upstream end of the shiftable sleeve. When the ball reaches this position, it exerts two separate actions. First of all, it blocks the through flow passage of the tubular casing. Secondly, as pressure builds up above the ball, the ball is able to force the sleeve downwardly against its spring loading to a rest position in which a port in the wall of the sleeve moves into registry with the port in the tubular casing. This then allows by-pass flow of fluid when required, to alleviate any problems arising during a drilling operation.

The tool remains "activated" in this mode for as long as is required, but when it is desired to de-activate the tool, a second de-activation ball is launched down the drill string. This second ball is a hard ball (usually made of steel) and which comes to rest against the first (activation) ball.

In this position of the second ball, it blocks access to the port in the sleeve, and therefore prevents further by-pass flow. Also, pressure builds up above the two balls, and this then causes the second ball to press against the first (deformable) ball and which

causes it to deform, or partially collapse, so that it can squeeze itself past the ball seat and move downwardly through the tubular casing until it is received by a ball catcher device (which also catches the second steel deactivation ball). This then deactivates the tool, in that the sleeve moves back under its spring loading to the blocking position with respect to the by-pass port, and allows normal through flow passage of fluid through the tubular casing to resume.

This known by-pass tool has been found to be particularly useful to drilling operators, and to solve many problems encountered during typical drilling operations.

It is a primary objective of the invention to provide improvement to this known by-pass tool, and to achieve still further technical advantages.

According to the invention there is provided a by-pass tool which is insertable into a drill string and which is operative in a first operating mode to allow throughflow passage of fluid and in a second operating mode to allow by-pass flow of fluid, said tool comprising:

a tubular casing defining a throughflow passage to allow fluid to flow lengthwise of the tool between inlet and outlet ends of the casing and each being communicable with the drill string;

a transverse by-pass port in the wall of the casing;

a control sleeve mounted in the casing for axial movement between first and second end positions corresponding to the first and second operating modes of the tool;

means biassing the control sleeve towards the first end position so as to block communication with the by-pass port and allow throughflow passage of fluid in the first operating mode;

a ball-receiving seat provided in the tool to receive a first deformable activating ball to be launched down the drill string when it is required to adjust the tool from its first operating mode to its second operating mode, said seat being operative when it receives the activating ball to move the sleeve from its first end position to its second end position against the action of the biassing means, and in which the first activating ball is deformable by the action of a second de-activating ball launched down the drill string so that the first ball can move lengthwise of the tool to be received by a ball catcher and thereby allow the sleeve to move back to its first end position under the action of the

biassing means when it is required to adjust the tool from its second operating mode to its first operating mode; and,

a releasable locking arrangement which can be actuated to a locking mode by the movement of the sleeve to the second end position in order to hold the sleeve in the second end position, said locking arrangement being disabled by movement of the first activating ball lengthwise of the tool during adjustment of the tool from the second mode to the first mode.

Thus, the invention provides a by-pass tool which can maintain the sleeve locked in its second end position, even in the event of a reduction in fluid pressure upstream of the ball, and which allows a number of different operating possibilities.

Thus, the by-pass port can effectively be locked open, and fluid can therefore drain when the drill string is pulled out of the wellbore. However, when necessary, the by-pass port can be simply closed by dropping the second deactivating ball and pressurising-up the drill string. A second advantage is that it is now possible to pump down the annulus or outside the pipe, allowing fluid flow to be pumped in reverse direction inwardly through the by-pass port and up the drill string.

Preferably, the sleeve has a communicating port in its wall, and which communicates internally with the interior of the tool, and externally with the by-pass port when the sleeve moves to the second end position.

In a preferred arrangement, the second ball blocks communication with the communicating port, after the second ball has been launched down the drill string, and this stops by-pass flow of fluid, and therefore allows the upstream fluid pressure to build-up, and which then causes deformation of the first activating ball to move lengthwise of the tool. The second ball follows this movement, and both balls are then captured by the ball catcher device.

Any suitable locking arrangement may be provided, but in a preferred arrangement a locking sleeve is movably mounted in the tool and is biassed to a release position. However, upon movement of the control sleeve to the second end position, a latch element may be triggered to latch the two sleeves together. This therefore maintains the tool in the second operating mode, regardless of whether or not the first activating ball

still continues to apply movement to the control sleeve in the direction towards the second end position and against the spring biassing.

A preferred embodiment of by-pass tool according to the invention will now be described in detail, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a side view, partly broken away to show the internal components, of a by-pass tool according to the invention, and adjusted to a first operating mode allowing throughflow passage of fluid;

Figure 2 is a view, similar to Figure 1, but showing the tool undergoing adjustment from the first operating mode to a second operating mode allowing by-pass flow of fluid;

Figure 3 is a view, similar to Figure 1 and 2, showing initial stages of deactivating the tool, so as to revert from the second operating mode back to the first operating mode; and,

Figures 1a, 2a and 3a are, respectively, views of the lower end of the tool and showing adjustment of the components corresponding with Figures 1, 2 and 3 respectively.

Referring first to Figures 1 and 1a of the drawings, this shows a by-pass tool 10 which is insertable into a drill string and which is operative in a first operational mode to allow throughflow passage of fluid, as shown in Figures 1 and 1a. However, the tool is adjustable to operate in a second operating mode to allow by-pass flow of fluid, as will be described with reference to Figures 2 and 2a. Finally, after activation of the tool to the by-pass mode, as shown in Figure 2, it can be deactivated, and this is shown in Figures 3 and 3a.

The by-pass tool 10 comprises a tubular casing 11 which defines a throughflow passage to allow fluid to flow lengthwise of the tool between inlet end 12 and outlet end 13 of the casing 11. The inlet and outlet ends 12, 13 of the tubular casing 11 each communicate with the drill string, and therefore allow throughflow of fluid, and lengthwise of the drill string, when the tool is in the first operating mode.

However, the tubular casing 11 has a transverse by-pass port 14 in the wall of the casing, and which allows by-pass flow of fluid, when the tool is adjusted to the second operating mode. A control sleeve 15 is mounted in the casing 11 for axial movement

between a first end position shown in Figure 1, and a second end position shown in Figure 2. These end positions correspond to the first and second operating modes of the tool.

Means is provided to bias the control sleeve 15 towards the first end position, and in the illustrated arrangement this comprises a main compression spring 16. In the first end position of the control sleeve 15, as shown in Figure 1, it blocks communication with the by-pass port 14, and therefore allows throughflow passage of fluid between the inlet 12 and the outlet 13 in this first operating mode.

A ball-receiving seat 17 is provided in the tool, preferably on the upper end of the sleeve 15, and which is arranged to receive a first large deformable activating ball 18 which is launched down the drill string when it is required to adjust the tool from its first operating mode to its second operating mode. The ball seat 17 is operative, when it receives the activating ball 18, to move the control sleeve 15 from its first end position shown in Figure 1, to its second end position shown in Figure 2, and against the action of the biassing spring 16.

This movement of the control sleeve 15 then allows the tool to operate in the by-pass mode, whereby fluid flow is possible through the by-pass port 14, and such flow can be either radially inwardly or radially outwardly.

However, when it is required to deactivate the tool, a second deactivating ball 19 is launched down the drill string, and this is a smaller hard ball, typically made of steel. The second ball 19 comes to rest at the upper end of the sleeve 15, and adjacent to the deformable ball 18, and in this position it blocks communication with the by-pass port 14. Therefore, the fluid pressure in the drill string above the tool builds-up, and this results in the application of a substantial downward force on the deformable ball 18, which deforms so that it is able to squeeze past the ball seat, and move lengthwise of the tool to be received by a ball catcher (not shown) and thereby allow the control sleeve 15 to adjust the tool from its second operating mode to its first operating mode.

A releasable locking arrangement is provided and which can be actuated to a locking mode by the movement of the control sleeve 15 to the second end position, and thereby to hold the sleeve in the second end position. However, the locking arrangement can be disabled by movement of the first activating ball 18 lengthwise of the tool during adjustment of the tool from the second mode to the first mode.

The control sleeve 15 has a communication port 20 which communicates internally with the interior of the tool, and externally with the by-pass port 14 when the sleeve moves to the second position, as shown in Figure 2.

The second deactivating ball 19 blocks communication with a communication port 20, after it has been launched down the drill string, and this stops by-pass flow of fluid, and therefore allows the upstream fluid pressure to build-up, and which then causes deformation of the first activating ball 18 to move lengthwise of the tool. The second ball 19 follows, and both balls are then captured by the ball catcher device.

The locking arrangement comprises a locking sleeve 21 which is movably mounted in the tool and which is biassed to a release position by a compression spring 22. However, upon movement of the control sleeve 15 to the second end position, a latch element is triggered to latch the sleeves 15 and 21 together. This therefore maintains the tool in the second operating mode, even when the first activating ball 18 no longer exerts downward force on the control sleeve 15.

In the by-pass tool known from US 5499687, the tool functions by dropping a deformable ball into a spring loaded sliding sleeve, which allows ports to align and for flow to be diverted out a large port in the wall of the tool. The tool is closed by dropping a steel ball which restricts flow out of the port in the sleeve, allowing the drill string to pressure-up. When a pre-set pressure is reached, the activating ball, namely the deformable ball blows through the sleeve with the steel deactivating ball following it into the ball catcher assembly that allows flow to circulate around the balls. In this known system, when the pumps are kicked-out, and there is zero flow, the return spring pushes the sleeve upward, thereby closing the by-pass port.

The embodiment of by-pass tool according to the invention has technical advantage, and allows for different operating possibilities. In particular, in the embodiment of the invention, the by-pass port 14 can be locked open. A first advantage of this is that the port can be locked open, and fluid can drain when the drill string is pulled out of the borehole. If necessary, it can be simply closed by dropping the deactivating ball and then pressuring-up the fluid in the drill string. A second advantage is that it is possible to pump down the annulus, or outside the pipe, allowing fluid flow to be pumped radially inwardly through the port and then back up the pipe.

Thus, in the embodiment of the invention, with the activating ball 18 seated on the mail sliding sleeve, pressure is applied which shifts the main sliding sleeve against the main spring, thereby aligning the ports 14 and 20. At the same time, a locking collet 23 pushes against the locking sleeve 21, allowing the locking collet 23 to fall into a locking bevel 24, at which point the locking sleeve 21 is pushed up by locking spring 22, thereby holding the locking collet 23 in position. The main sliding (control) sleeve 15 therefore maintains ports 14 and 20 in alignment, thus locking the by-pass system in the open condition.

When it is necessary to close the tool, the sleeve deactivating ball 19 is dropped down the drill string, and the system pressures-up. When the activating ball 18 blows through the main ball seat 17, the activating ball 18 continues to move lengthwise of the tool until it reaches an unlocking ball seat 25 (see Figure 1a), and which therefore triggers release of the locking arrangement. Thus, the fluid pressure builds-up behind the activating ball 18, and the unlocking ball seat 25 therefore moves the locking sleeve 21 downwardly against the action of spring 22, allowing the locking collet 23 to move freely out of engagement with the locking bevel 24. This therefore allows the main spring 16 to return the main control sleeve 15 to its original (first end) position. This is achieved by reason of the fact that the main sleeve 15 is threaded to the locking collet 23. As this is happening, fluid pressure continues to build-up in the tool, and then blows the activating ball 18 through the unlocking ball seat 25 and into the ball catcher assembly (not shown).

During the deactivating process, the deactivating ball 19 will always have a positive pressure pushing it against the port 20 in the main sliding sleeve 15. When the tool deactivates and unlocks, the deactivating ball simply follows the activating ball through both ball seats (17 and 25) and into the ball catcher assembly.

CLAIMS

1. A by-pass tool which is insertable into a drill string and which is operative in a first operating mode to allow throughflow passage of fluid and in a second operating mode to allow by-pass flow of fluid, said tool comprising:

a tubular casing defining a throughflow passage to allow fluid to flow lengthwise of the tool between inlet and outlet ends of the casing and each being communicable with the drill string;

a transverse by-pass port in the wall of the casing;

a control sleeve mounted in the casing for axial movement between first and second end positions corresponding to the first and second operating modes of the tool;

means biassing the control sleeve towards the first end position so as to block communication with the by-pass port and allow throughflow passage of fluid in the first operating mode;

a ball-receiving seat provided in the tool to receive a first deformable activating ball to be launched down the drill string when it is required to adjust the tool from its first operating mode to its second operating mode, said seat being operative when it receives the activating ball to move the sleeve from its first end position to its second end position against the action of the biassing means, and in which the first activating ball is deformable by the action of a second de-activating ball launched down the drill string so that the first ball can move lengthwise of the tool to be received by a ball catcher and thereby allow the sleeve to move back to its first end position under the action of the biassing means when it is required to adjust the tool from its second operating mode to its first operating mode; and,

a releasable locking arrangement which can be actuated to a locking mode by the movement of the sleeve to the second end position in order to hold the sleeve in the second end position, said locking arrangement being disabled by movement of the first activating ball lengthwise of the tool during adjustment of the tool from the second mode to the first mode.

2. A by-pass tool according to claim 1, in which the sleeve has a communicating port in its wall, and which communicates internally with the interior of the tool, and externally with the by-pass port when the sleeve moves to the second end position.

3. A by-pass tool according to claim 1 or 2, and arranged such that the second ball blocks communication with the communicating port, after the second ball has been launched down the drillstring, in order to stop by-pass flow of fluid, and thereby allow the upstream fluid pressure to build-up and then cause deformation of the first activating ball to move lengthwise of the tool.

4. A by-pass tool according to claim 3, including a ball catcher device arranged to capture both balls from the tool.

5. A by-pass tool according to any one of claims 1 to 4, in which the locking arrangement comprises a locking sleeve which is movably mounted in the tool and is biased to a release position.

6. A by-pass tool according to claim 5, and arranged such that, upon movement of the control sleeve to the second end position, a latch element is triggered to latch the two sleeves together.

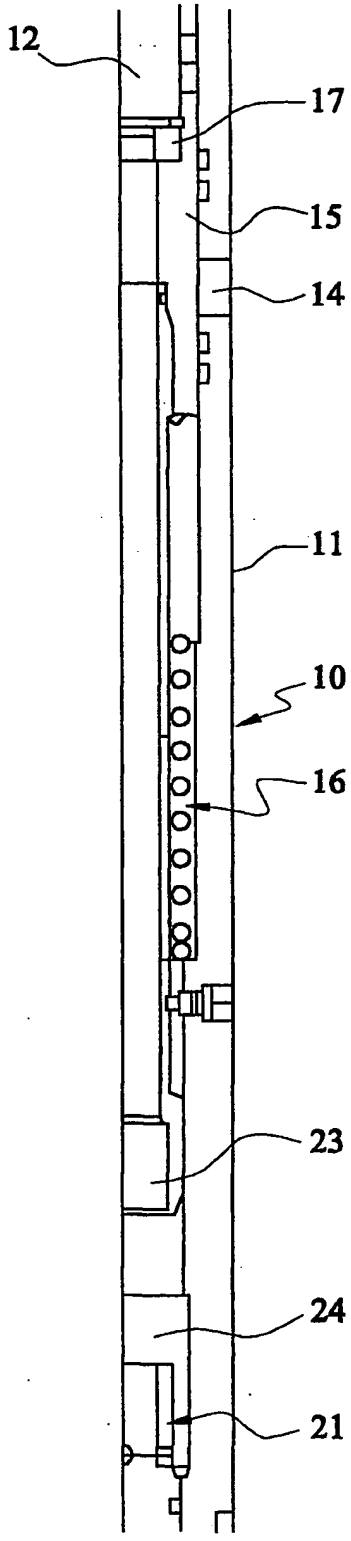


FIG. 1

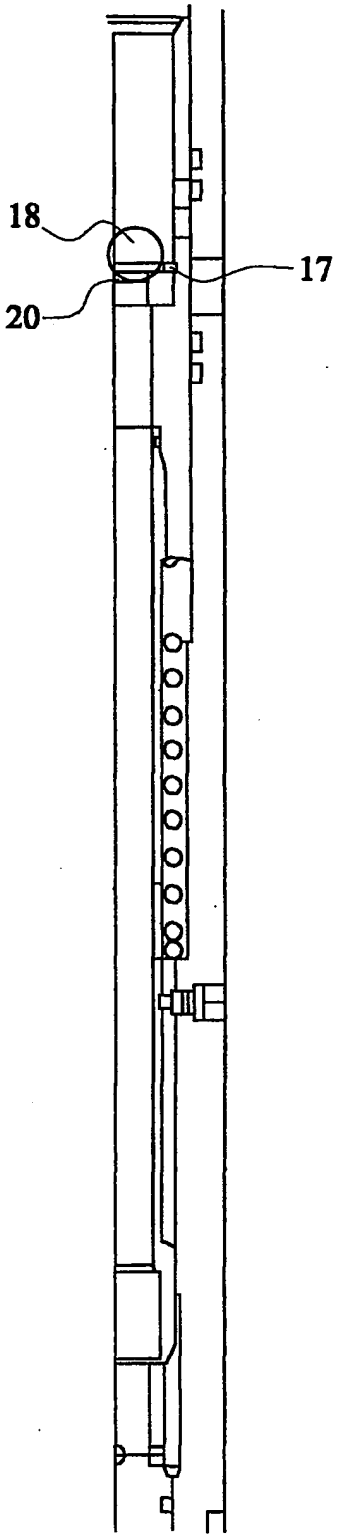


FIG. 2

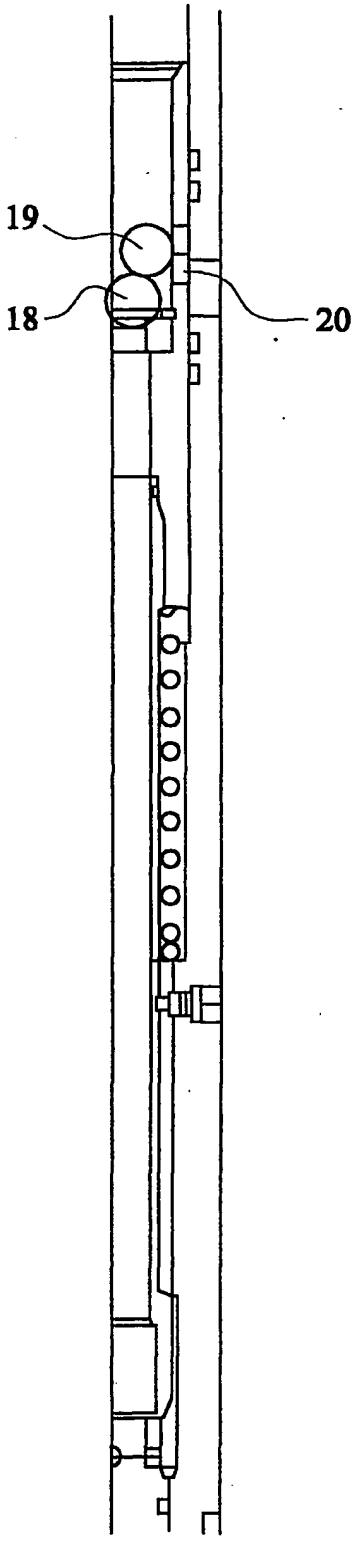


FIG. 3

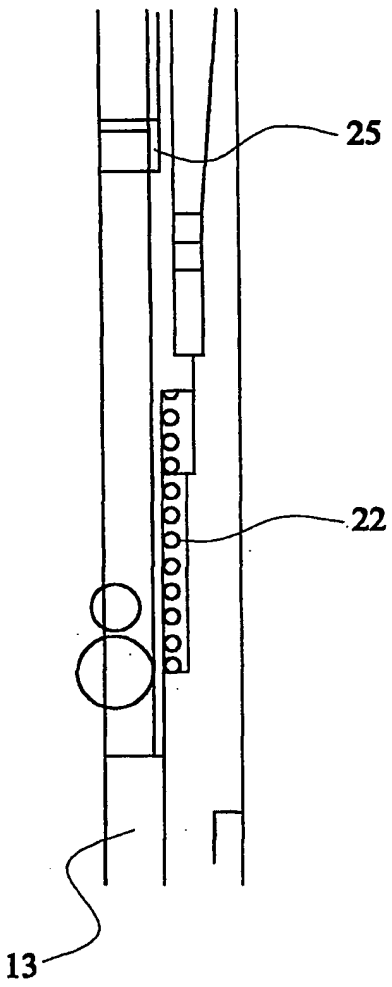


FIG. 1a

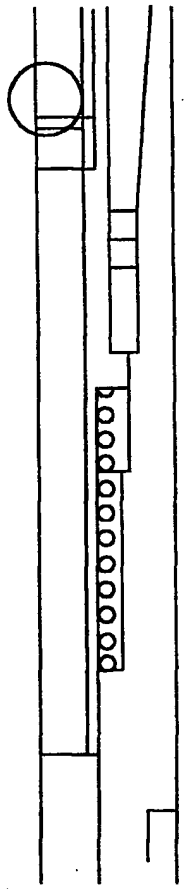


FIG. 2a

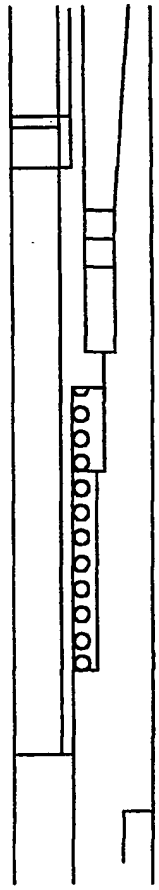


FIG. 3a